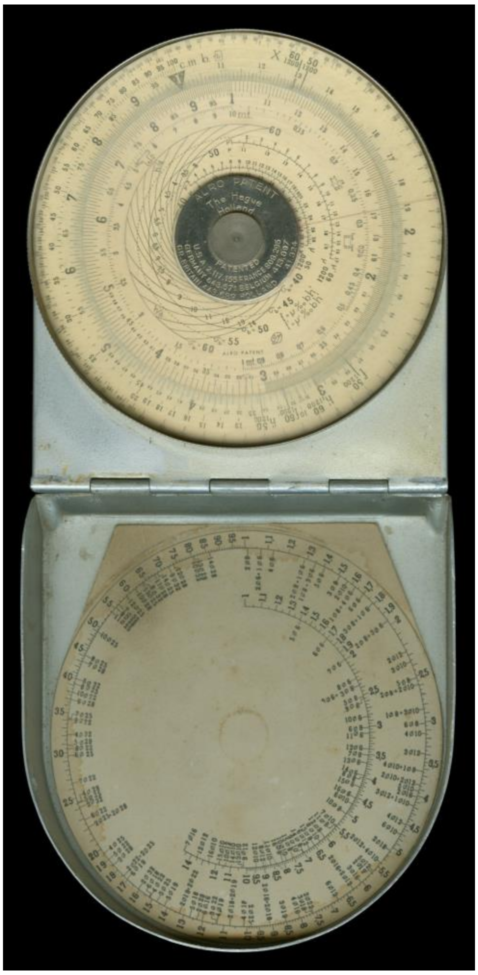
De ALRO Concrete Rule — Chris Hakkaart



Boek over ALRO

Otto van Poelje is druk bezig met het samenstellen van een boek over ALRO. Dat zal begin 2020 uitgegeven worden.

Een van de ALRO-exemplaren die daarin vermeld worden, betreft een rekenschijf voor betonberekeningen. Op Otto's verzoek heb ik een beschrijving/handleiding opgesteld. In het boek zullen namelijk geen uitgebreide beschrijvingen opgenomen worden, maar wel vele andere kenmerken worden vermeld.

Rekenschijven voor betonberekeningen
Opvallend -maar ook wel bekend - is, dat diverse rekenschijven voor betonberekeningen niet één op één met elkaar vergelijkbaar zijn. Beton is voornamelijk een empirisch gebruikt materiaal, waardoor er meestal met verhoudingen wordt gewerkt, die verschillend zijn per land. Uiteindelijk zullen resultaten van berekeningen niet veel van elkaar afwijken, maar de hoeveelheid wapening voor een vaste balkafmeting bijvoorbeeld, kan per land wel iets verschillen. Gelukkig worden overal strikte en grote veiligheidsfactoren gehanteerd, zodat de resultaten toch betrouwbaar zijn.

De deelnemers aan de IM2019 vinden op de bijgeleverde USB credit card een werkend model van deze betonschijf en van andere schijven. Andries de Man heeft de gave om van statische foto's bewegende bruikbare schijven te maken.

Engelstalige beschrijving
The metal box is equal to other ALRO slide rule boxes. But it has no name related to concrete or a number like other ALRO slide rules. On the central metal plate patent numbers for USA, France, Germany, Belgium, Gr. Britain and Holland are mentioned. Also on the paper disk it is mentioned "ALRO Patent".

The scales show that this disk is designed for concrete calculations. The disk has a fixed centre part with multiple scales and curves and a rotating outer part with scales.

There is no manual available. The explanation has been based on basic concrete formulas and comparison with other concrete slide rules.

The rotating disk has the following scales from outside to inside:

- A non-linear spiral anti-clockwise scale from 25 to 150, which rotates 1.5 times the disk. The number 100 equals with the number 1 of the logarithmic scale. The purpose is not clear.
- A logarithmic quadratic scale (usually known as A) from 13 to 100. The 100 is in line with the 10 of the logarithmic scale. It has also the notation cm, the letter b (= width) and the pictogram of a beam.
- A logarithmic scale (usually known as C).
- At one location the letter "X" with the numbers 60/1200 and 50/1200 are present with a mark to the logarithmic scale. The 50 and 60 represent the concrete quality by means of the allowable concrete compression stress of 50 or 60 kgf/cm^2. The 1200 is the allowable steel tension stress in kgf/cm^2. This slide rule is designed for this combination of concrete compression and steel tension stresses. These marks are used for the determination of the concrete compression zone "X" on scale D.
- At another location the letter "f" with the same combinations of 50/1200 and 60/1200 is present, with a mark to the logarithmic scale. The letter "f" represents the area of steel cross-section per unit width at the tension side. These marks are used for the determination of the steel cross-section of a 1 cm wide beam on scale D.
- At another location the letter "h' " with the same combinations of 50/1200 and 60/1200 is present, with a mark to the logarithmic scale. The letter "h' " represents the section height (height minus concrete cover) of a beam on scale D. NOTE: mostly the character h is used for this distance.

The fixed part of the disk has the following scales from outside to inside:

- A logarithmic scale (usually known as D).
- A logarithmic quadratic scale from 0.1 to 10 with the notation m.t. This represents the Moment on the beam in meter·ton (we usually say ton·meter). The number 10 is equal to the 1 of the logarithmic scale.
- The notation M/bh^2.
- Formula f = μ ‰ b h'. The width of a beam is b. The section height (height minus concrete cover) of a beam is h'. The reinforcement quantity per unit width at the tension side (mostly the underside of a beam) is μ. The area of steel cross-section per unit width at the tension side is f. The total amount of reinforcement As = f * width. In hand calculations mostly the character A is used.
- Scales for a rectangular beam (next to a pictogram) for the combinations 60/1200 and 50/1200. These scales can be used for finding the μ or μ' or the h or h'.

Curves

Curves are provided next to a pictogram for the " h'/d " (the total height to flange height ratio) for a T-Beam. The section height (total height minus concrete cover) of a beam is h'. The "d" is the thickness of the flange. The relation counts from 3 to 14, which crosses with the concrete qualities 40, 45, 50, 55 and 60 kgf/cm^2.

By moving the red arrow to the crossing of the concrete quality and h'/d, the correction factor in relation to a rectangular beam can be found on probably the D scale. With this value it should be possible to follow the marks for a rectangular beam. However this could not be checked.

At the bottom are handwritten initials with the letters C J D, which are the initials of the designer of this slide rule: C.J. Dussel.

Cursor
On top of the disk is a thin transparent circular cursor with a red hairline

Manual
The use of the ALRO slide rule: no manual is available.

There are general accepted concrete calculation methods and besides that different countries have had their own rules and calculation methods. All concrete slide rules are made for methods of calculating concrete in the period before the Eurocodes and before approximately 1975. From the seventies on, the national concrete codes have changed and replaced by the Eurocodes.
In the IM 2003 Proceedings Pierre van der Meulen has presented a paper about concrete slide rules. An explanation is given about the formulas and methods used and how to use several concrete slide rules. Sometimes manufactures used the real values of the parameters, but others used their own fixed relations between parameters (e.g. steel and concrete stresses). This has probably to do with patents.
For this ALRO concrete slide rule the same example has been used as in Pierre's article.

Known variables:

- [M] = Moment 747.94 kgf·cm: on scale with code mt and position the red cursor.
- [b] = beam width 20 cm: used the cm b scale and place this value under the cursor opposite the [M].
- Read the result 0.37 on the quadratic [M].
- Because the quadratic scales [M] and [b] were used, the square root of this value has to be used for the next steps of the calculation. This is 6.1. This can be done by using the C and D scales.
- Put the red cursor on the 6.1 on the D scale.
- Rotate the 1 on the C scale under the red cursor.
- The marks at the combination of [steel stress] = 1200 kgf/cm^2 and [concrete stress] = 60 kgf/cm^2 are on different positions for "X", the concrete compression zone, for "f", the steel area and for " h' ", the section height.
- [X] = 7.9 cm found on the D scale opposite the mark 60/1200.
- [h'] = 18.4 found on the D scale under the mark h 60/1200. Concrete calculations often used h.
- [f] steel area per unit width = 0.197 found on the D scale under the mark 60/1200. The [As] = 0.197 * 20 = 3.94 cm^2

Inside of the box
The scales on the inside of the box consist of a complete logarithmic circular scale from 1 to 100, equal to the scale on the fixed part on the main disk and a logarithmic half circular scale.

At the inside of both scale numbers and diameters are printed opposite the values which corresponds with the area of reinforcement [As]. This is done for all for all types of combinations of numbers and steel diameters. So when the minimum required steel area is calculated, the reinforcement solution can be directly found by using the logarithmic scale as mm^2 scale.
Due to the large amount of rebar combinations, a double scale is used. In our example of 3.94 cm^2, the choice has to be made between at least 2 bars of 16 mm or 14 bars of 6 mm diameter (which does not fit in a beam of 20 cm). Assume that for practical reasons 4 bars are preferred, than 4 bars of 12 mm diameter with an area of 4.18 cm is a solution. A check of the amount of steel along the scale shows that it fits exactly, except for one: the notations of 13 ø 28 and 10 ø 32 have been switched.